

$$\begin{cases} V_{AN} = V_{AG} + V_{GN} \\ V_{BN} = V_{BG} + V_{GN} \\ V_{CN} = V_{CG} + V_{GN} \end{cases}$$

somma  $V_{AG} + V_{BG} + V_{CG} = 0$

$$V_{AG} = V_{AN} - V_{GN}$$

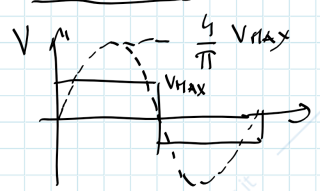
$$V_{GN} = \frac{V_{AN} + V_{BN} + V_{CN}}{3}$$

Consente di alimentare a  $f$  variab

=> MODULAZIONE A ONDA QUADRA (A SEI GRADINI)

=> MIN. NUMERO DI ACC/SPEGN. COMMUTAZIONE

DIFETTO => Non posso cambiare Valore della tensione applicate



$$\begin{cases} V_{AN} = \frac{4}{\pi} \frac{V_{dc}}{2} \left( \sin \omega t + \frac{1}{3} \sin 3\omega t + \frac{1}{5} \sin 5\omega t + \frac{1}{7} \sin 7\omega t + \dots \right) \\ V_{BN} = \frac{4}{\pi} \frac{V_{dc}}{2} \left( \sin \left( \omega t - \frac{2\pi}{3} \right) + \frac{1}{3} \sin 3 \left( \omega t - \frac{2\pi}{3} \right) + \frac{1}{5} \sin 5 \left( \omega t - \frac{2\pi}{3} \right) + \dots \right) \\ V_{CN} = \frac{4}{\pi} \frac{V_{dc}}{2} \left( \sin \left( \omega t + \frac{2\pi}{3} \right) + \frac{1}{3} \sin 3 \left( \omega t + \frac{2\pi}{3} \right) + \frac{1}{5} \sin 5 \left( \omega t + \frac{2\pi}{3} \right) + \dots \right) \end{cases}$$

$$V_{AN} = V_{AG} + V_{GN}$$

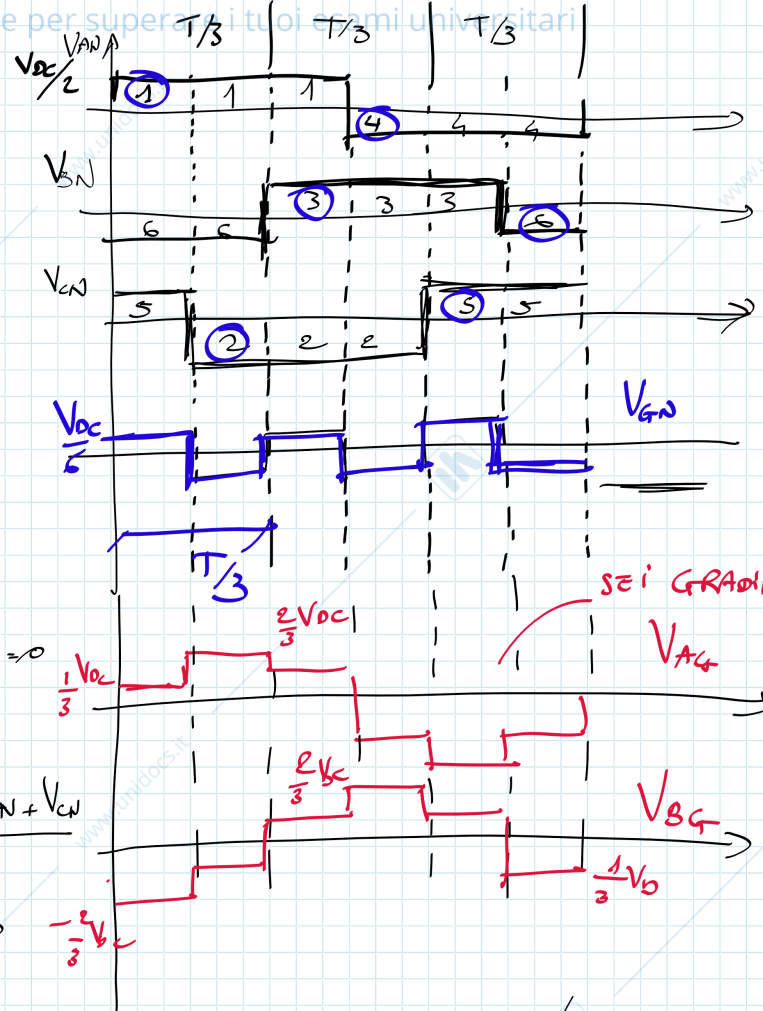
$$V_{AN_3} = \frac{1}{3} \sin 3\omega t \quad V_{BN_3} = \frac{1}{3} \sin 3\omega t \quad V_{CN_3} = \frac{1}{3} \sin 3\omega t \quad \leftarrow \text{Sono in fase!}$$

$V_{AN_3} + V_{BN_3} + V_{CN_3} \neq 0$

$$V_{AG} + V_{BG} + V_{CG} = 0 \quad V_{AG}, V_{BG}, V_{CG} \text{ non ci sono le armoniche } \times 3$$

le arm arm  $\times 3$  sono tutte in  $V_{GN} (1/3) = \frac{V_{AN} + V_{BN} + V_{CN}}{3}$

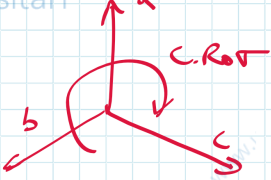
$V_{AG}, V_{BG}, V_{CG} \Rightarrow$  tutte le altre  $\Rightarrow 1, 5, 7, 11, 13, \dots$



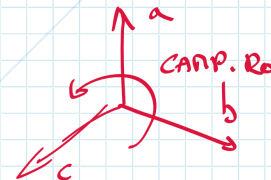
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$\textcircled{A}$   $\sin 8\omega t$        $\textcircled{B}$   $\sin 5\left(\omega t - \frac{2\pi}{3}\right)$        $\sin 5\left(\omega t + \frac{2\pi}{3}\right)$   
 $(\cancel{5\omega t - \frac{10\pi}{3}})$        $(\cancel{5\omega t + \frac{10\pi}{3}})$   
 $-\frac{4\pi}{3}$        $+\frac{4\pi}{3}$   
 $\omega t$        $(\omega t + \frac{2\pi}{3})$        $(\omega t - \frac{2\pi}{3})$   $\Rightarrow$  **terna inversa**




$\textcircled{A}$   $7\omega t$        $7\omega t - \frac{14\pi}{3}$        $7\omega t + \frac{14\pi}{3}$   
 $+\frac{12\pi}{3} \leftarrow$  (mult. di  $2\pi$ )  
 $7\omega t$        $(7\omega t - \frac{2\pi}{3})$        $(7\omega t + \frac{2\pi}{3})$   $\Rightarrow$  **terna diretta**



$\downarrow$  6      12      18      24      30  
 1      -5      7      -11      13      -17      19      -23      25      -29      31  
**INVERSA**      **DIRETTA**

$V_{AG} + V_{BG} + V_{CG} = 0$



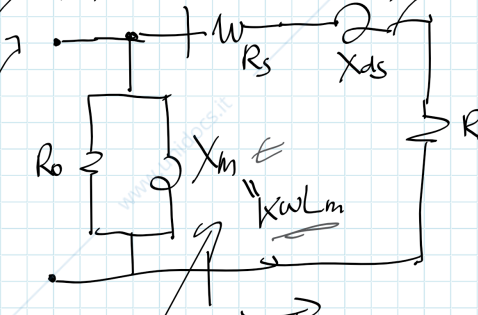
$\textcircled{3}$   $\sin 3\omega t$        $\sin 3\left(\omega t - \frac{2\pi}{3}\right)$   
 $\downarrow$   $\sin 3\omega t$

$V_{AG} = 1 \left(\frac{1}{3}\right) \frac{1}{5}$

$\Rightarrow$  Solo se amp  $\Rightarrow$  tutto realizza  $\frac{1}{3}$  arm.

$V_{AN} = V_{AG} + V_{GN}$

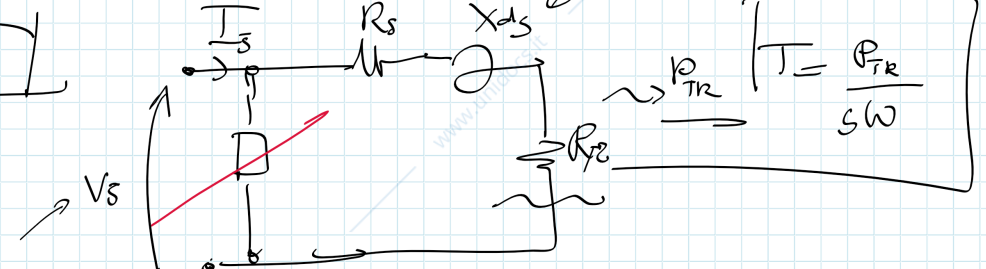
$\textcircled{1}$  **armonica**  $\Rightarrow$  come l'abbiamo studiata  
 $X = \frac{\omega - \omega_m}{\omega} = 1\%$   
 $I_s = \frac{V_{AGs}}{Z} = \frac{V_{AG1}}{5} \Rightarrow I_s \Rightarrow \frac{1}{25} \text{ A}$   
 $j\omega L_m$

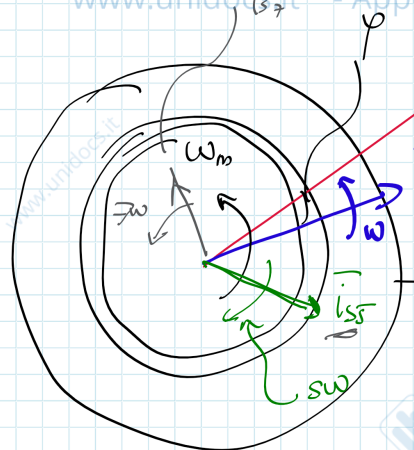


Gli effetti mag. verso il rotore sono dovuti solo alla 1<sup>a</sup> armonica.  
 $\omega_m \Rightarrow$  dipende solo dalla prima armonica  
 $\omega_m \approx \omega$   
 $X = \frac{5\omega - \omega_m}{5\omega} \approx \frac{4}{5}$        $X = \frac{7\omega - \omega}{7\omega} = \frac{6}{7} \rightarrow 1$

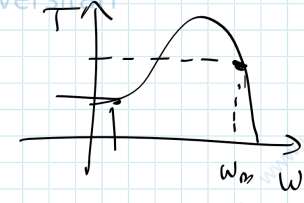
**AR successive alla 1**

$I_s$        $R_s$        $X_{ds}$   
 $V_s$        $R_{TR}$        $P_{TR} = \frac{P_{TR}}{5\omega}$





$$T = k i_{s1} i_{r1} \sin \varphi$$



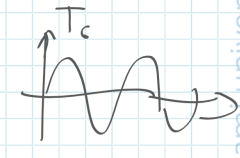
$$\omega_r = \omega - \omega_m$$

$i_{r1}$  non cambia! xché non dipende dalle armoniche succ.

$T_s$  = coppia pulsante xché l'angolo  $\varphi$ ,  $i_{s1}$  e  $i_{r1}$  continua a variare

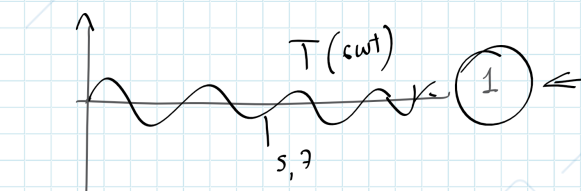
$$T_s = k \sin(\omega - (-s\omega)) = k^* \sin(6\omega t) = k i_{s1} i_{r1} \sin(6\omega t)$$

coppia pulsante a  $6\omega$



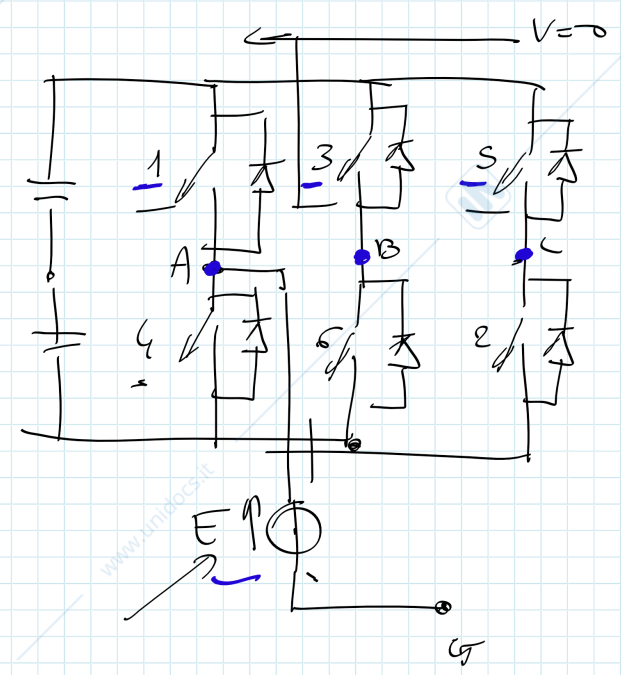
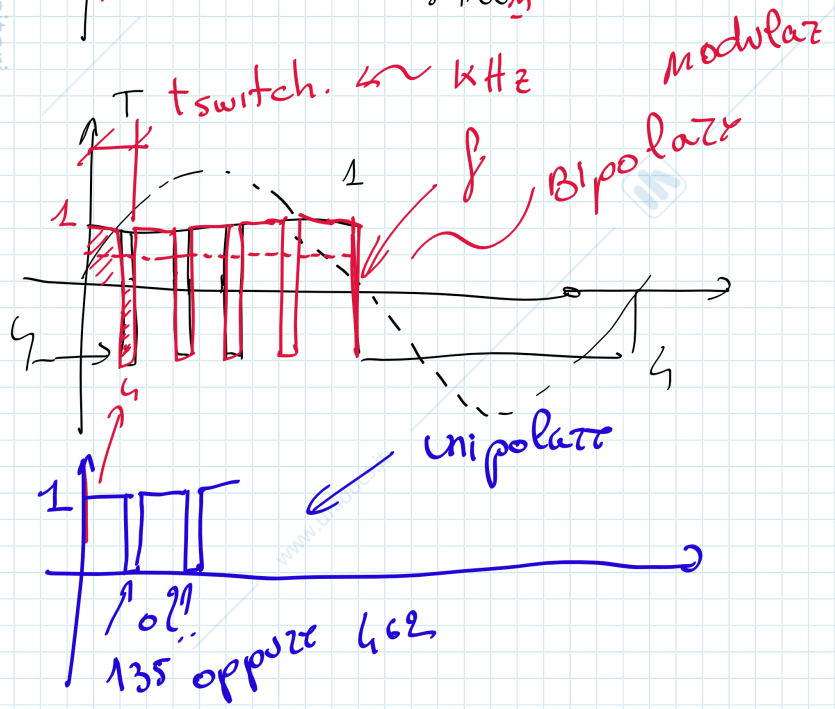
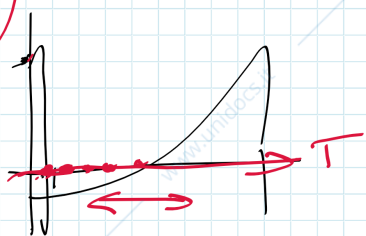
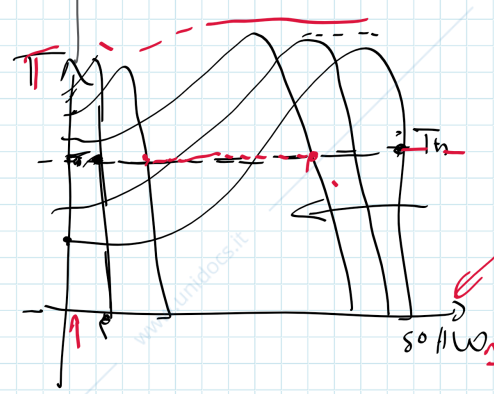
$$T_7 = k^* \sin((\omega - 7\omega)t) = k^* \sin 6\omega t$$

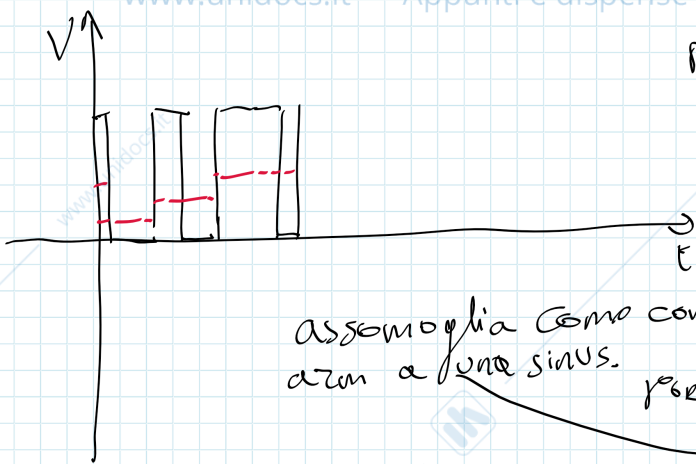
coppia pulsante a  $6\omega$



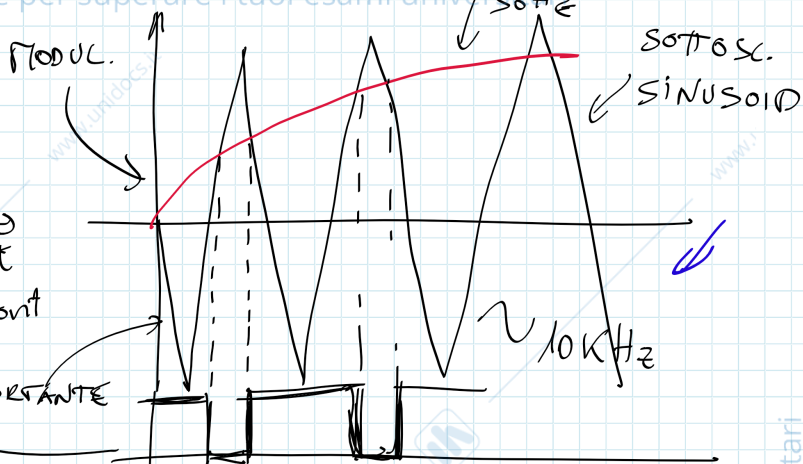
$$\frac{V}{f} = \text{cost}$$

diminuire  $V \equiv f$

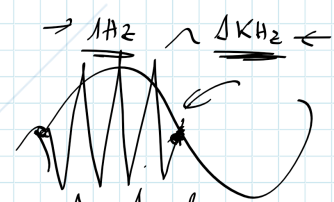




assomiglia come cont  
arm a una sinus.



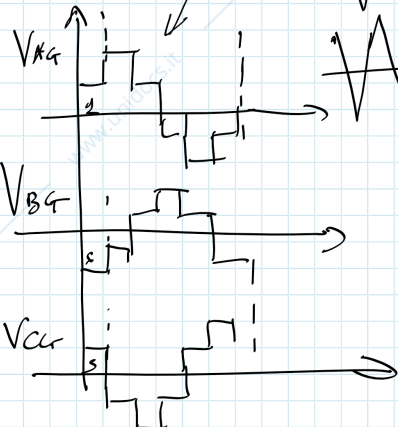
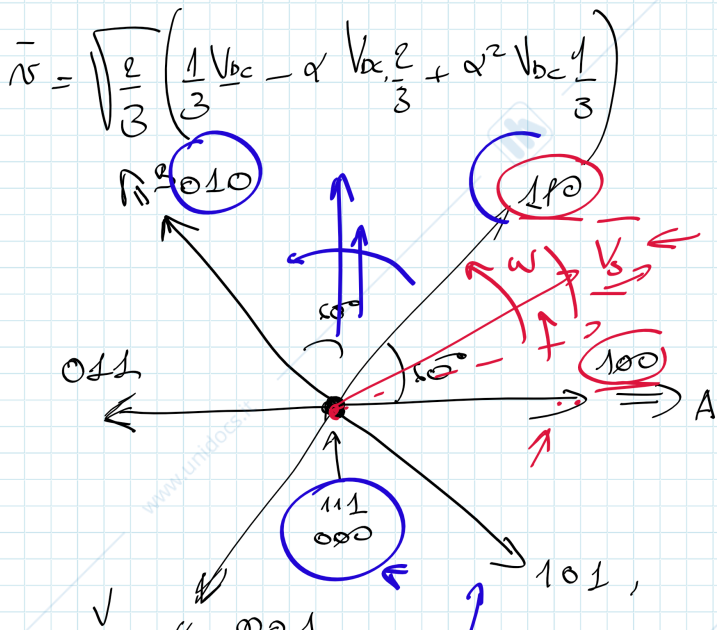
1<sup>a</sup> arm alla freq. della modulante  
le succ. sono attorno alla f. della port.



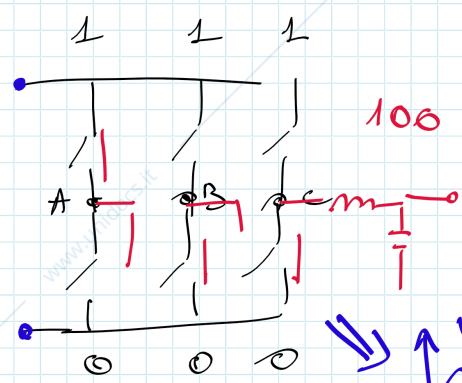
**SPACE VECTOR MOD.**

$$\vec{v} = \sqrt{\frac{2}{3}} (v_a + \alpha v_b + \alpha^2 v_c)$$

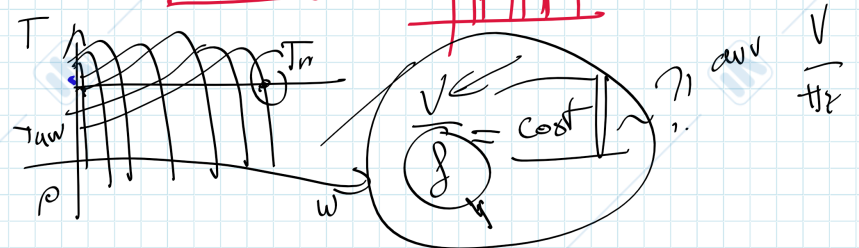
↑  
nel tempo



- ① 3 ⑤
- ④ ⑥ 2



**SVM**



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